Rotational dependence of the proton-transfer reaction $HCl^+ + HCl \rightarrow H_2Cl^+ + Cl$

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The chemistry of gaseous ions is important for understanding a variety of processes for instance in interstellar clouds, plasma chemistry and analytical mass spectrometry. In order to understand and eventually control ion-molecule reactions, it is necessary to investigate the influence of translational and internal energy on these reactions separately. We have recently described an approach for measuring cross section for ion molecule reactions as a function of the collision energy and the internal quantum state of the ion (1,2). Here, we present a study of the rotational dependence of the proton-transfer reaction of HCl^+ in the electronic, spin-orbit and vibrational ground state with neutral HCl. State-selected HCl^+-ions with rotational quantum numbers controllable from 0 up to 10 were prepared by resonance enhanced multiphoton ionization (REMPI) (3). A guided ion beam apparatus was used to measure cross section σ as a function of the reactant ion rotational excitation and of the collision energy (1). The cross section for the title reaction decreases with increasing collision energy, as expected for exothermic reactions. For collision energies between 0.2 and 1.0 eV the cross section decreases with increasing rotational energy of the ion for rotational energy between 0 and 35 meV. For the highest rotational energies investigated the cross section increases again, indicating a change in the dynamical bottleneck. For collision energies above 1.0 eV σ becomes basically independent of the rotational quantum state of the ion. Complementary experiments utilizing deuterated hydrogen chloride (DCl) are currently under way in our laboratory. The current results for the exothermic proton transfer are compared to previous data for the reaction $HBr^+ + CO_2 \rightarrow HOCO^+ + Br$ (1,2).

References

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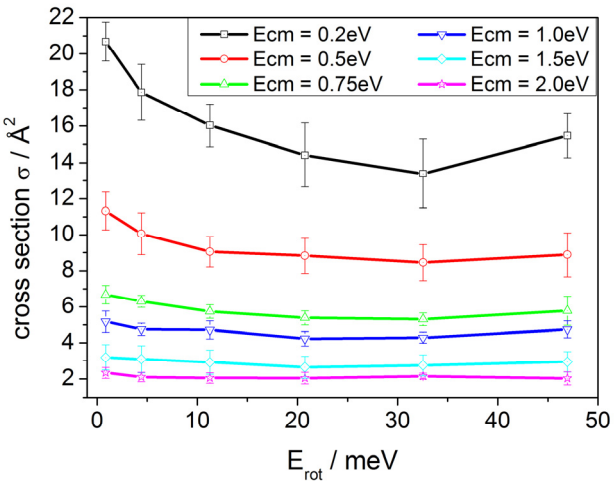

Fig. 1 Absolute cross section for the title reaction as a function of (state-selected) rotational energies at different center of mass collision energies (Ecm) as indicated.

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